Study of Tropopause Height over Buenos Aires Monitored with lidar system.

Susan Gabriela Lakkis **(1,2)**, ***Mario Lavorato*** **(3,4)**, ***Pablo Osvaldo Canziani*** **(2,5)**

[1] Facultad de Ciencias Agrarias, Pontificia Universidad Católica Argentina, Cap. Gral. Ramón Freire 183, C1426AVC, Buenos Aires, Argentina, gabylakkis@uca.edu.ar, canziani@uca.edu.ar.
[2] PEPACG (Pontificia Universidad Católica Argentina - CONICET), Cap. Gral. Ramón Freire 183, C1426AVC, Buenos Aires, Argentina, gabylakkis@uca.edu.ar
[3] División Radar Láser, CEILAP (CITEFA-CONICET), Juan B. La Salle 4397, B1603ALO, Villa Martelli, Buenos Aires, Argentina, mlavorato@citefa.gov.ar, mpagura@citefa.gov.ar
[4] Grupo TAMA, Universidad Tecnológica Nacional, Facultad Regional Haedo, París 680, Haedo, Buenos Aires, Argentina, mlavorato@citefa.gov.ar, mpagura@citefa.gov.ar
[5] Consejo Superior de Investigaciones Científicas y Técnicas (CONICET), Argentina, canziani@uca.edu.ar.

ABSTRACT: The atmospherics dynamic processes in the upper troposphere (UT) and the lower stratosphere (LS) have much interest due to their important role and impact of cirrus clouds on the atmospheric radiative balance. The dynamics range of backscatter lidar signals let us to observe and improve our knowledge of cirrus clouds as well as to calculate the principal atmospheric parameters in the troposphere. The present work attempts to analyse the tropopause height and its evolution in time in the UT/LS region. The lidar system let us measure in real time the evolution of cirrus clouds and the tropopause height in daytime and nighttime. We present the preliminary results to monitor the tropopause height and their temporal evolution using a backscatter lidar system located at Buenos Aires (34.6°S, 58.5°W). The system operates at 532 nm, with a great dynamic range, starting from 50 m above the ground up to 20 km in daytime and up to 27 km in nighttime [1]. Different cirrus clouds measurements are considered during 2001 - 2005, in order to estimate tropopause height and its temporal evolution, using the top of cirrus clouds present on the UT as a tropopause tracer

Key words: cirrus clouds, lidar, tropopause height.

1. INTRODUCCTION

Understanding the physics and chemistry of the processes involved in the upper troposphere and the low stratosphere (UT/LS), as well as troposphere – stratosphere exchange (STE), has become one of the major scientific and technical challenges for the next years due to the strong evidence that the Earth′s climate is changing (IPCC, 2007). The UT/LS is a critical region for understanding climate: the dynamical, radiative and chemical connections between the troposphere and the stratosphere are a topic of great importance that must be understood in order to advance in the understanding of global climate change. For this purpose, reliable quantitative information on transport properties between these two regions, as well as temperature structure and trends among others parameters, is required.

The tropopause is recognized, as a key feature of the atmospheric structure at all latitudes; i.e., polar, mid-latitudes and tropics, and an overall understanding both of the UT/LS and of stratosphere-troposphere exchange (STE) is dependent on our ability to quantify and describe tropopause structures and their evolution in time (Hoinka, 1998; Holton et al., 2006; Shepherd, 2002; Stohl et al.,2003).

The tropopause layer can thus be viewed as the transition zone between the turbulently mixed troposphere and the more stable stratified stratosphere (Seidel et al., 2006), affecting both the dynamics and the chemistry.

The exchange of mass, water, and other trace gases between the troposphere and stratosphere takes place across the tropopause. In this scenario the tropopause plays an exceptional role (Hoinka, 1998).

One of the most important issues concerned to the lidar system is capability for studying dynamics processes and climatology of the troposphere and stratosphere as well as the posibility to obtain in real time the altitudes of the layer of different atmospheric components (Campbell, J. B., 2007). In this sense, one of the direct applications of the lidar is to analyze the cirrus clouds and subsequently, to study the tropopause behavior. Many radiative transfer studies show that the cirrus clouds have a net warming effect on the top of the troposphere and within the lower stratosphere, but a net cooling effect on the surfaces; the microphysical and radiative properties are not well characterized. Cirrus has also been pointed to as a possible surface for heterogeneous reactions that could impact ozone concentrations in the UT/LS.

The cirrus clouds appear below the tropopause, especially in the tropics (Beyerle et al., 1998) and they have been observed also above the local tropopause at mid-latitudes (Goldfarb et al, 2001) and polar regions (Formenti et al., 1999; Klett, 1981). Therefore, monitoring tropopause cirrus clouds height and its evolution might be considered to be a new alternative, highly accurate way to study the tropopause height: tropopause cirrus clouds can be viewed as tropopause tracers. The aim of the present work is to provide insights on ten comparable datasets derived from rawinsonde and lidar system on mid-latitudes cirrus, respectively, from Southern Hemisphere, more specifically cirrus over Buenos Aires, Argentina, in order to analyse the tropopause height when they are compared with the rawinsonde data.

2. **DATA AND METHODOLOGY**

For tropopause height study, only the high resolution lidar signals are considered, which corresponds to a logarithmic scale plot for the electric pulse range corrected. These signals are mathematically processed in three stages in order to correct the range of the scale, filter the noise and obtain the best signal to noise ratio. The final lidar signal is averaged with 500 laser shots.

By adjusting with a linear fit, the slope of the high resolution signal up to the point where the cirrus ends, it is possible to detect the tropopause height as the altitude of the last point of the cirrus clouds signal (Fernald, 1984; WMO, 1992). This technique should be considered a graphic method to detect the tropopause height with a confidence interval of about 500 meters. Here we use the conventional tropopause height as given by WMO.

This is defined as the lower boundary layer of an atmospheric layer in the UT in which the temperature lapse rate is less than 2° C/km and this layer has to be at least 2 km thick (WMO, 1992). This definition is referred to as the thermal tropopause, and is the definition used in the operational rawinsonde profiles retrievals. Nevertheless, many recent studies have dealt with the tropopause in tropics, i.e. Tropical Tropopause Layer (TTL) and Extratropical Tropopause Layer (ExTL). As pointed out the Intergovernmental Panel on Climate Change (IPCC), 2007, the mechanisms that result in the ExTL formation are different from those that result in the TTL formation. Besides, this layer, through which STE occurs, varies from 0.5 km in the tropics to 6 km in the extra-tropics region.

As the cirrus analyzed over Buenos Aires are usually located near the top of the troposphere, the altitude of the cirrus top is taken to represent the tropopause height. Moreover, the tropopause height is more accurately determined when the signal is clear enough to show not only the end of the cirrus but also the change of the lapse rate of the processed signal, which corresponds to a lower stratospheric signal. In this case, cirrus clouds occur in a boundary layer between the troposphere – stratosphere, corresponding to the transition zone. Thus monitoring the temporal evolution of the cirrus top, it is possible to obtain the tropopause evolution in real time.

The measurements derived from lidar system were compared with the local rawinsonde provided by the Argentine ‘Servicio Meteorológico Nacional’ (SMN) located at Ezeiza (International Airport code: SAEZ), in order to evaluate the accuracy of the lidar system. The data set form SMN is taken to 00 UTC and 12 UTC when they are available.

3. RESULTS

Cirrus monitoring was continuously carried out for up to nine consecutive hours at most for each event. The temporally averaged lidar signal profiles were recorded with 6 m of vertical resolution. We analyze and study 10 cirrus clouds signal from 2001-2005. The profiles collected correspond to diurnal signals. Each event represents a certain number of profiles for a specific year, month, day and time period (in UTC hours) compound by instantaneous and periodicals measurements.

Figure 1 displays two examples of the complete cirrus cloud dataset collected for the present analysis. The tropopause altitude was calculated using the slope method as described in the previous section. Figure 2 and 3 show the tropopause height measured simultaneously with lidar and rawinsonde as example of the applied method. The data corresponds to August 1st, 2001 and September 13th, 2004. Table 1 summarizes the results for the ten cases here presented. The numerical data corresponds to tropopause height derived from rawinsonde and lidar signal for each event. These values may be compared with few others climatological studies due to the fact that cirrus clouds at Southern Hemisphere are not extended characterized, but the tropopause height derived from radiosonde network is a well known parameter (Bischoff et al., 2007).

In this sense, the results (Table 1) reveal that the cirrus cloud top derived from lidar present a remarkable good agreement compared with rawinsonde data, with value differences of less than 550 meters depending principally on the signal to noise ratio of lidar data

As was mentioned in the introduction, lidar system has the capability of reproduce the tropopause evolution in real time. This evolution can be measured in a constant way during several hours, depending on different factors that may affect the lidar system performance: the weather and climate processes as well as the signal noise ratio for each event are some of the most determinant factors.

Figures 4 shows the cirrus clouds time series evolution for August 1st, 2001. Due to the fact that the top of cirri stays aligned with the tropopause height for the cases under study, it could be noted that the top evolution of the cirrus clouds also represents the tropopause evolution. Thus, it is possible to assume that top cirri over Buenos Aires, can be viewed as tropopause tracers.

4. CONCLUSIONS

The present work provides insights about the capability of a lidar system located at Buenos Aires to monitor the upper troposphere, particularly the tropopause height and its evolution. Table 1 show that tropopause height derived from lidar signals is found to be in the range 10.7 to 13.7 km, with a confidence range of 0.5 km. Even when there are few climatological studies at Southern Hemisphere related to this topic, the tropopause height values are in close agreement with those derived from rawinsonde, as in the recent tropopause climatology by Bischoff et al. (2007)

By the other hand, the study highlights that the cloud top of these cirri under analysis, stays aligned very closely with the tropopause layer at this latitude-longitude range. In this sense, Figure 4 displays a characteristic evolution of the cirrus top and cirrus base. As the cirrus clouds cases under study present the same top behaviour it is possible to surmise that cirrus top could be considered as tropopause tracers. From this point of view, the analysis reveals that lidar system can be viewed as an alternative way to monitor and to improve our knowledge about the transition layer, with high accuracy with the main advantage of lower cost than similar continuous monitoring with rawinsonde launches.

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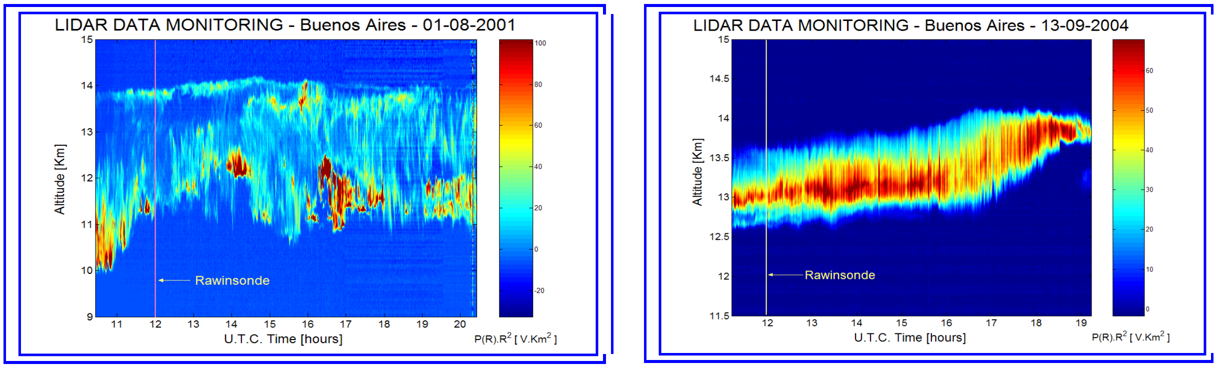

Figure 1. Two cases of cirrus observations during 2001-2005. Range-corrected 532-nm signals with 50-s and 6-m resolution.

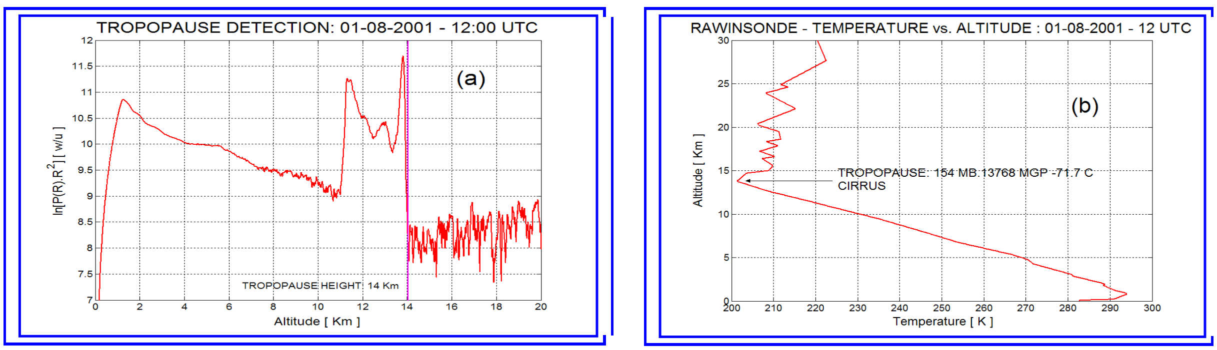

Figure 2. (a) Linear regression of the signal slope to calculate tropopause height compared with rawinsonde (SMN) data (b) corresponding to August 1st , 2001.

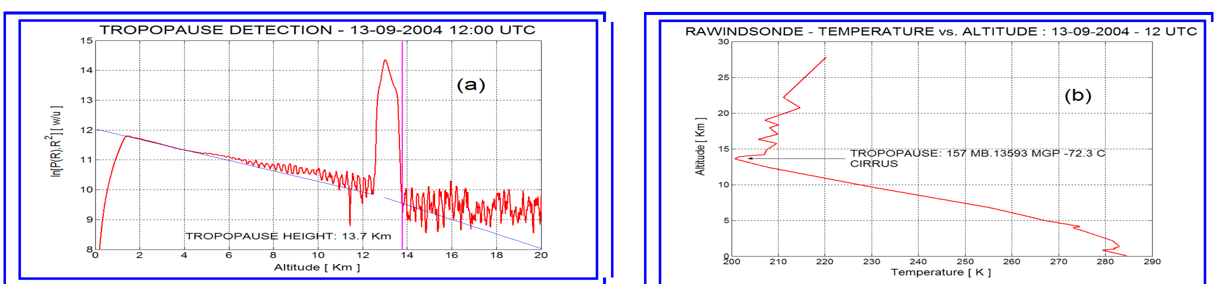

Figure 3. The same as Figure 2 but for September 13th, 2004.

Table 1. Tropopause height from rawinsonde vs. top cirrus with lidar system

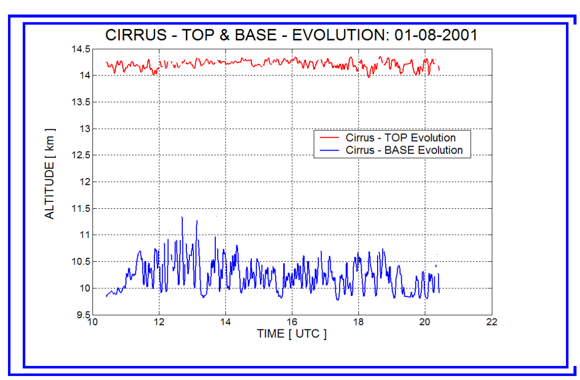

Figure 4.

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